Decomposition Analysis of the Waste Composting in Croatia

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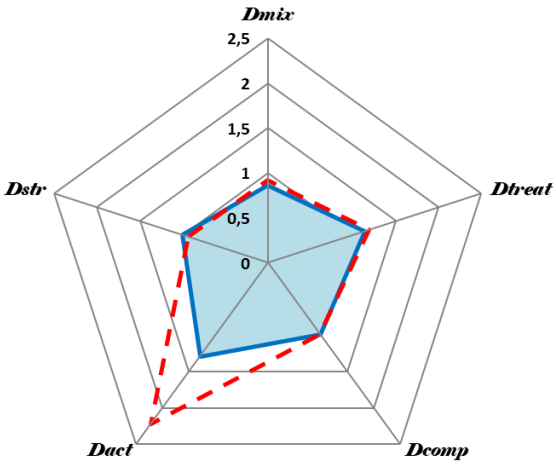
Among the methods commonly used to treat organic waste like for e.g. landfill or incineration, composting is considered one of the most beneficial for the environment. Composting is a complex biochemical process that utilizes microorganisms under aerobic conditions to promote the transformation of biodegradable organic matter to sanitized compost products (Chen et al., 2023; Wei, et al., 2017). However, there are certain shortcomings causing the reduction in composting extensive usage and efficiency, which include pathogen presence, low nutrient status, long duration of the composting and odour presence (Rocchia et al., 2023; Ayilara et al., 2020). Present waste management systems use source-separated collection of bio-waste from the population and agri-food industries and treat these wastes by composting, vermicomposting, or in anaerobic digestion facilities; producing compost and biogas as renewable energy source (Zhou et al., 2022). As assessed by Eurostat, in the year 2021, 44.89 million tonnes of municipal waste were composted/digested in the EU-27 compared to 236.8 million of tonnes of municipal waste generated (Eurostat, 2023).

The data decomposition analysis has a wide range of applications in the energy and environment fields such as energy efficiency, greenhouse and air pollutant emissions, plastic consumption and solid waste generation and management (Zou et al., 2022; Zhao,et al., 2022). Out of all various decomposition analysis methods for quantitatively analysing the data, logarithmic mean Divisia index (LMDI) is the most studied and widely applied method as it determines and ranks the causal effects and because it results in complete decomposition (zero residual) (Koilakou et al., 2023; Xiang et al., 2022). However, there have been very little attempts to create software solutions to help potential users with complex and time-consuming calculations (Xiang et al., 2022). As presented in this paper, the practitioners create the LMDI model by themselves based on the type and properties of the data and the wanted outcome. Generally, LMDI decomposes the quantitative difference between two years on influential factors (three or more), ranked by its own share in that total difference.

In this paper the annual changes in in the amounts of the organic waste which can be treated by composting was analysed. Analyses covered the amounts of waste collected, sent for treatment to composting facilities and the amounts composted in the certain counties of the Republic of Croatia. 10 out of 21 counties in Croatia conduct biodegradable waste composting operations: Grad Zagreb, Zagrebačka county, Primorsko-goranska county, Zadarska county, Osječko-baranjska county, Koprivničko-križevačka county, Sisačko-moslavačka county, Krapinsko-zagorska county, Varaždinska county, and Međimurska county. In the Republic of Croatia it is mandatory for waste collection and/or treatment facilities to report the data to Croatian Environmental Pollution Register (CEPR). The data on the following waste streams for the period 2017-2021 from the CERP specified by the European Waste Codes was used in this analysis (29 waste streams total): 02 01 01; 02 01 03; 02 01 06; 02 01 07; 02 01 99; 02 02 03; 02 02 04; 02 03 01; 02 03 04; 02 06 01; 02 07 01; 02 07 04; 03 01 05; 03 01 99; 03 03 01; 15 01 03; 15 01 09; 17 05 06, 19 05 01; 19 08 05, 19 08 12; 19 08 14; 19 09 03; 20 01 08; 20 01 25; 20 01 38; 20 01 39 i 20 02 01. In the period analysed in this paper the quantities of waste suitable for composting which was collected have increased 288%. In the same period quantities of waste composted have almost tripled in the amount (from 110 thousand tonnes to 317 thousand tonnes). All this indicates that there is still much room for growth.

The data on bio-waste collection and composting were decomposed to find out whether the change in an aggregate (difference between a total amount of waste composted between two observed years) was associated with some of the five influencing effects:

- waste collection activity effect (D_{act}) – change in an overall level of the activity in all counties between two observed years,
- structural effect (D_{str}) – change in counties' shares in an overall activity level of all 10 counties,
- waste mix effect (D_{mix}) – change in a amounts and types of waste streams collected in a certain county,
- treatment effect (D_{treat}) – change in a share of a collected amount of a particular waste stream which was received by the composting facility to be composted and
- composting effect (D_{comp}) – change in a share of a particular waste stream which was composted.



Dstr: structure effect; Dact: activity effect; Dmix: waste mix effect; Dtreat: treatment effect; Dcomp: composting effect.

Figure 1. Average results of the decomposition of influencing components on the amounts of composted waste in Croatia in the period 2017 – 2021 (blue); Results of the decomposition of influencing components on the amounts of composted waste in Croatia between the years 2017 and 2021 (red).

The results show that in average (blue line in the Figure 1) the most dominant effect were the changes in the waste collection activity (D_{act}) – increase in the collected amounts of waste suitable to be composted increased the amounts which were composted actually, indicated in the Figure 1 by the value higher than 1. Change in a share of a collected amount of a particular waste stream which was received by the composting facility (D_{treat}) also had an observable effect. Insignificant effects were the D_{str} and D_{comp} (value below 1). The results of the decomposition analysis of the composted waste in Croatia by comparing the years 2017 and 2021 (red line in Figure 1) show the influence of the D_{act} very distinct from the other effects. Thus, it can be concluded that the increase in the bio-waste collection capacity was the main driver of the increase in the total amounts of composted waste. Another interesting finding was that the change in a amounts and types of waste streams collected (D_{mix}) had a value less than 1, indicating that there are biodegradable waste streams less fitting for composting and are more likely to be managed by some other option (e.g. incinerated).

This paper demonstrates the possibility of applying the LMDI approach to scientifically determine factors that drive the improvements in the waste management system as well as to show the causes of the in the unwanted results of that system. The findings of this paper have importance for the national and international level policymakers to make educated decisions by learning from the past experience and to evaluate the implemented measures in order to enable the achievement of the prescribed goals of diverting biodegradable waste from landfills and lowering greenhouse gasses emissions.

REFERENCES

Ayilara, M. S., Olanrewaju, O. S., Babalola, O. O. & Odeyemi, O., 2020. Waste Management through Composting: Challenges. Sustainability 12, 4456, pp. 1-23.

Chen L., Chen Y., Li Y., Liu Y., Jiang H., Li H., Yuan Y., Chen Y., Zou, B., 2023. Improving the humification by additives during composting: A review. Waste Management, Volume 158, pp. 93-106.

Eurostat, 2023. Eurostat Database. [Online]
Available at: https://ec.europa.eu/eurostat/data/database
[Accessed 07 14 2023].

Koilakou, E., Hatzigeorgiou, E. & Bithas, K., 2023. Carbon and energy intensity of the USA and Germany. A LMDI decomposition approach and decoupling analysis. Environmental Science and Pollution Research, Volume 30, p. 12412–12427.

Rocchia, G., Reho, M., Bevilacqua, A. & Pileri, J., 2023. Relation between psychological, psycho-cultural factors and attitudes towards the construction of a composting/vermicomposting plant: a case study. Psychology Hub, Volume XL (1), pp. 81-86.

Wei, Y. Wei Y., Cui M., Ye Z., Guo Q., 2017. Environmental challenges. Resour Conserv Recycl, Volume 122, pp. 51-65.

Xiang, X.; Ma, X.; Ma, Z.; Ma, M.; Cai, W., 2022. Python-LMDI: A Tool for Index Decomposition Analysis of Building Carbon Emissions. Buildings 2022, Volume 12 (83), pp. 1-13.
Zhao, X., Liu, H. & Ding, L., 2022. Decomposition analysis of the decoupling and driving factors of municipal solid waste: Taking China as an example. Waste Management, Volume 137, pp. 200-209.
Zhou, Y., Ran, X., Thomas, K., Xiaoliang, K., Binghua, Y., Florin-Constantin, M., Tao, L., Zengqiang, Z., Awasthi, Mukesh Kumar, A., 2022. Recent trends and advances in composting and vermicomposting technologies: A review. Bioresource Technology, Volume 360, pp. 1-13.
Zou, X., Li, J. & Zhang, Q., 2022. CO2 emissions in China's power industry by using the LMDI method. Environmental Science and Pollution Research, Volume 30, p. 31332–31347.